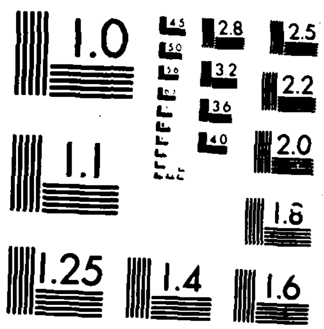
AD-A164 526 IRREGULAR FREQUENCIES IN SHIP MOTION PROBLEMS(U) 1/1
DELAWARE UNIV NEWARK DEPT OF MATHEMATICAL SCIENCES
T ANGELL ET AL. JAN 86 N00014-83-K-0060

UNCLASSIFIED F/G 13/10 NL

END
FILMED
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

1

IRREGULAR FREQUENCIES
IN SHIP MOTION PROBLEMS

Angell, Hsiao and Kleinman

Final Report

Contract No. N00014-83-K-0060

University of Delaware
Department of Mathematical Sciences

January 1986

FINAL REPORT

UNIVERSITAS DELAVARIENSIS
SCIENTIA MENTIS SOL EST
1833

DEPARTMENT
OF
MATHEMATICAL SCIENCES

University of Delaware
Newark, Delaware

IRREGULAR FREQUENCIES
IN SHIP MOTION PROBLEMS

Angell, Hsiao and Kleinman

Final Report

Contract No. N00014-83-K-0060

University of Delaware
Department of Mathematical Sciences

January 1986

FINAL REPORT

REPORT DOCUMENTATION PAGE

1a REPORT SECURITY CLASSIFICATION: UNCLASSIFIED	1b RESTRICTIVE MARKINGS: N/A
2a SECURITY CLASSIFICATION AUTHORITY: N/A	3 DISTRIBUTION/AVAILABILITY OF REPORT: APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED
2b DECLASSIFICATION/DOWNGRADING SCHEDULE: N/A	
4 PERFORMING ORGANIZATION REPORT NUMBER(S): None	5 MONITORING ORGANIZATION REPORT NUMBER(S)
6a NAME OF PERFORMING ORGANIZATION: Dept. of Mathematical Sciences University of Delaware; 6b OFFICE SYMBOL (If applicable)	7a NAME OF MONITORING ORGANIZATION: DAVID W. TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER, Code 1504 (1505)
6c ADDRESS (City, State, and ZIP Code): Newark, Delaware 19711	7b ADDRESS (City, State, and ZIP Code): BETHESDA, MARYLAND 20084-5000
8a NAME OF FUNDING/SPONSORING ORGANIZATION: Naval Sea Systems Command; 8b OFFICE SYMBOL (If applicable): SEA 05R24	9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER: Contract Number - N00014-83-K-0060
8c ADDRESS (City, State, and ZIP Code): Washington, D. C. 20360	10 SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO	PROJECT NO	TASK NO	WORK UNIT ACCESSION NO
61153N	SR 023 01	23454	N/A

11 TITLE (Include Security Classification)

(U) IRREGULAR FREQUENCIES IN SHIP MOTION PROBLEMS

12 PERSONAL AUTHOR(S)

T. Angell, G. C. Hsiao & R. E. Kleinman

13a TYPE OF REPORT	13b TIME COVERED	14 DATE OF REPORT (Year, Month, Day)	15 PAGE COUNT
FINAL	FROM Oct 82 TO Sep 85	Jan 1986	6

16 SUPPLEMENTARY NOTATION Sponsored under the Naval Sea Systems Command General Hydromechanics Research (GHR) Program administered by the David W. Taylor Naval Ship R&D Center, Code 1504(1505), Bethesda, Maryland 20084-5000

17 COSATI CODES

FIELD	GROUP	SUB-GROUP
20	04	

18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number)

GHR Program,

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

This final report summarizes the scientific accomplishment and effort on Contract N00014-83-K-0060, "Irregular Frequencies in Ship Motion Problems," under the General Hydromechanics Research Program for the period of 1 October 1982 to 30 September 1985.

The three main areas of research are: the floating body problem (zero forward speed), the Kelvin-Neumann problem (non-zero favored speed), and the application of optimization methods. Comments are made on each separately.

20 DISTRIBUTION/AVAILABILITY OF ABSTRACT: ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION: UNCLASSIFIED
22a NAME OF RESPONSIBLE INDIVIDUAL: Mr. V. J. Monacella	22b TELEPHONE (Include Area Code): 202-227-1503; 22c OFFICE SYMBOL: Code 1504/1505

Final Report

This final report summarizes the scientific accomplishment and effort on Contract Number N00014-83-K-0060, Irregular Frequencies in Ship Motion Problems, under the General Hydrodynamics Research Program for the period 1 October 1982 to 30 September 1985.

The three main areas of research are: the floating body problem (zero forward speed), the Kelvin-Neumann problem (non-zero favored speed), and the application of optimization methods. We comment on each separately.

(1a) The Floating Body Problem (3-dimensional). In his classic work on the floating body problem, F. John showed how the boundary value problem could be reduced to an integral equation over the wetted portion of the ship hull. The kernel of his integral operator was the Green's function for the entire fluid domain with no ship present which satisfies the boundary condition at the bottom of fluid (assumed flat) and the linearized free surface condition on the entire fluid-air boundary. John demonstrated the existence of irregular frequencies: frequencies for which the integral equation was not uniquely solvable.

Another way to treat this problem is to employ a much simpler Green's function, one which only satisfies the boundary condition at the bottom of the fluid. Since the Green's function does not satisfy the free surface condition, there results an integral equation over both the wetted surface of the ship hull and the free surface. Such an integral equation has been derived and even solved numerically for certain cases by Yeung and Bouger and Bai and Yeung. Numerical evidence indicated that this

integral equation does not exhibit irregular frequencies but no conclusive analytical argument had appeared to support this conjecture.

In this period, we have eventually verified this conjecture and provided a proof that this integral equation indeed has no irregular frequencies. Specifically, we have treated the three dimensional floating body problem with finite depth. Preliminary results were presented in the International Workshop on Ship and Platform Motions, University of California, Berkeley, October 26-28, 1983. The details and final results are included in our manuscript entitled "An Integral Equation for the Floating Body Problem", which has been accepted for publication in the Journal of Fluid Mechanics.

(1b) The Floating Body Problem *(2-dimensional). We have also been* successful in extending this approach to the corresponding two-dimensional floating body problem. As is well known in contrast to the three-dimensional case, the fundamental solution of the two-dimensional Laplace equation possess a logarithmic singularity. This causes some difficulty in removing boundary integrals over the fictitious vertical boundaries far from the ship when Green's formula is applied to derive the corresponding representation formula and boundary integral equation for this problem. However, with a slight modification, we are able to derive, as in the three-dimensional case, an integral over both the wetted surface of the ship hull and the free surface. Results of this approach have been presented in the H-5 Panel

meeting at the Society of Naval Architects and Marine Engineers in New York, November 14, 1985.

Numerical approximations for the solving of the corresponding integral equation are presently under investigation by Y.W. Liu a graduate student under our direction. Some numerical results will be reported in the forthcoming First International Workshop on Water Waves and Floating Bodies, MIT, 17-19 February 1986. As will be seen, these results are in excellent agreement with those obtained by Bai and Yeung using entirely different methods. The present approach appears advantageous because the computational scheme can easily accommodate changes both in wave number and in hull geometry. Details concerning this modified boundary integral equation for the two-dimemsional floating body problem will be given in the dissertation of Mr. Liu and we hope that it will be available soon.

(2) The Kelvin-Neumann Problem. The Kelvin-Neumann problem was the subject of intense study during Prof. Ursell's visit in the summer of 1983. The first question considered was whether a uniqueness proof, comparable to John's in the zero forward speed case, could be found in this case. The second question considered was whether John's geometric restriction could be weakened. Our answers to both questions are affirmative with limitations. We have derived a uniqueness proof in the two-dimensional finite depth case for partially submerged bodies moving at supercritical forward speed ($kh<1$). This result depends on reformulating the problem in terms of the stream function and therefore is limited

to two-dimensional problems. Also the restriction to supercritical speeds excludes many realistic cases of interest. Publication of this result has been deferred in hopes that continued research will enable the results to be more generally valid. This is one area in which it is planned that work will go on.

With regard to relaxation of John's restriction that vertical rays from the free surface intersect the ship hull at most once, Prof. Ursell has reported success using an idea that was developed initially during his visit to Delaware under the grant. John's restriction came about in deriving an integral inequality by integrating along vertical rays from the bottom to the free surface. It was thought that this could be extended if there existed rays straight, but not necessarily vertical, which connected every point of the free surface to the bottom. Then an inequality similar to John's could be derived by integrating along these rays. Ursell has reportedly succeeded in this plan with results presented at the British Theoretical Mechanics Congress, Newcastle-upon-Tyne, England, 1984. Again the restriction two dimensions appears essential.

3. The Optimization Problem. The optimization problem is that of choosing a ship hull configuration satisfying reasonable *a priori* constraints (e.g. lower bounds on the beam width) which will optimize given design criteria (e.g. minimize added mass). For technical reasons we have concentrated on the fully submerged body with zero forward speed. The problem is formulated as a constrained optimization problem whose cost functional (e.g. added

mass) is a domain functional. Continuity of the solution of the boundary value problem with respect to variations of the boundary is established in an appropriate function space setting This is used to establish existence of an optimal shape and it is shown how finite dimensional approximate solutions may be found.

Our preliminary results on the optimal design problem for the submerged body were presented for the first time in the European Boundary Element Seminar, Darmstadt, West Germany, November 1-3, 1984, and the final results were reported in the SIAM Spring Meeting, Pittsburgh, PA., June 24-26, 1985. The details are available in our manuscript entitled "An Optimal Design Problem for Submerged Bodies", which has recently been accepted for publication in the International Journal of "Mathematical Methods in the Applied Sciences". A continuation of this portion of the project has been planned and will concentrate on the numerical computation of the optimal solution and on the extension of these results to the surface case.

Papers and Presentations under Contract No. N00014-83-K-0060

T.S. Angell, G.C. Hsiao and R.E. Kleinman, An Integral Equation for the Floating Body Problem, J. Fluid Mechanics, to appear. Also available as University of Delaware Applied Mathematics Institute Technical Report 149A, 1984.

T.S. Angell, G.C. Hsiao and R.E. Kleinman, An Optimal Design Problem for Submerged Bodies, Math Methods in the Applied Sciences, to appear. Also available as University of Delaware Applied Mathematics Institute Technical Report 154A, 1984.

T.S. Angell, G.C. Hsiao and R.E. Kleinman, An Integral Equation for the Floating Body Problem, International Workshop on Ship and Platform Motions, Berkeley, CA, Oct. 26-28, 1983.

G.C. Hsiao, An Optimal Design Problem in Fluid Dynamics, European Boundary Element Seminar, Darmstadt, West Germany, Nov. 1-3, 1984.

T.S. Angell, G.C. Hsiao and R.E. Kleinman, An Optimal Design Problem for Submerged Bodies, SIAM Spring Meeting, Pittsburgh, PA., June 24-26, 1985.

R.E. Kleinman, The Two-Dimensional Floating Body Problem, H-5 Panel, Soc. Naval Arch. and Marine Eng., New York, Nov. 14, 1985.

Yung-Wey Liu, A Simplified Boundary Integral Method for the Two-Dimensional Floating Body Problem, First Workshop on Water Waves and Floating Bodies, MIT, Cambridge, MA, Feb. 16-18, 1986.

END

FILMED

3-86

DTIC